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## Overview of lead recycling

This section provides a brief introduction to lead acid batteries and an overview of the recycling industry.

The predominant use of lead within the world is in lead acid batteries. Lead acid batteries are an essential component of the automotive industry for which there are currently no electro-chemical, economic or environmentally acceptable or competitive alternatives. World wide it is estimated that between 300 and 350 million lead acid batteries are produced each year (Angus Environmental Ltd, 1993; Behrendt & Steil; Wilson, 1993).

With the continuing growth in urbanisation and private vehicle ownership, particularly within newly industrialised countries, the steady increase in demand for automotive batteries is likely to continue, guaranteeing an international demand for lead (Angus Environmental Ltd, 1993; OECD, 1993). It is estimated that by the year 2005 approximately 74% of the total lead utilised within the western world will be in the form of lead acid batteries (Ahmed, 1996).

The average life cycle of an automotive battery is approximately 3 to 4 years. Many years ago spent lead acid batteries (batteries which fail to retain an electrical charge) were disposed of within municipal landfills, with significant adverse environmental consequences. Therefore, in many industrialised countries the recycling of lead acid batteries is seen as an appropriate response to reducing the environmental effects associated with landfill disposal, while also realising the economic potential that could be achieved through recycling. Since there is a growing world demand for lead, in particular in rapidly industrializing countries of the South, it was expected that these economic benefits would be sustained through the operational lifetime of the technology (Sancilio, 1995; UNEP, 1995).

Recycled (or secondary) lead is now estimated to constitute about 60% all the lead produced. This rate is predicted to increase to over 65% by the year 2005. Over the same period the demand for lead is also expected to increase, but the level of primary lead production will remain almost static. Therefore, battery recycling technologies are seen as an increasingly important component in the production of lead (Ahmed, 1996).

The most common lead recycling process involves the automated breaking and sorting of batteries into their components, before the lead is extracted at high temperatures (smelting). Once refined and alloyed with other metals, the

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extracted lead is cast into ingots and made available for use in commercial applications.

In addition to the lead content of the battery, other components and by-products can also be recycled. For example, sulfuric acid reclaimed during the breaking process can be transformed into other marketable chemical products (such as detergent additives and fertilizers). Similarly, the propylene cases of batteries can be shredded and washed to produce clean polypropylene chips suitable for reconstitution. These may then be formed into other products, including battery cases (de Feraudy, 1993; Jackson & Tansel, 1994). Some automotive batteries contain up to 70% recycled plastics and 80% secondary lead (Worden, cited in Jackson and Tansel, 1994).

However, the recycling process also has the potential for significant environmental impacts and risks to human health and safety. Generally the more notable environmental impacts include particulate (including lead and other heavy metals) and acidic (sulfur dioxide - SO<sub>2</sub> and possibly some hydrochloric acid in the gaseous form, HCl) discharges into the atmosphere during the smelting and refining processes; the discharge of contaminated industrial waste and the leakage of acidic electrolyte during battery storage. The growing recognition of such impacts within communities, and by regulatory authorities, has been paralleled by the tightening of environmental protection standards and by higher environmental protection costs for recycling plant operators (Suttie, 1995; Wilson, 1993).

Internal costs, environmental controls and fluctuating lead prices have often impacted on the viability of any strictly profit-orientated recycling industry within western societies (Elmer, 1995; Suttie, 1995; Wilson, 1993). Although lead acid battery consumption within OECD countries continues to rise, there are few economic incentives for expansion of smelting facilities in developed nations. In contrast, lead consumption in rapidly industrializing (developing) countries has been rapidly expanding, often at rates of 10-15% per annum in volume terms. Many of these countries suffer from a domestic supply-demand gap for lead. Apart from increased imports of primary lead, this gap has also been closed by imports of scrap batteries from developed countries. Currently Asian nations such as Indonesia, India, and Thailand are the principal recipients of used lead acid batteries. (Elmer, 1995) In this regard, the fear has been expressed that such North-South shipments of scrap vehicle batteries are fuelled by lower operating costs of recycling facilities (for instance in terms of labour, health and environmental costs), which make such operations more competitive and economically viable (Greenpeace, 1994).

While not yet in force, the Basel Ban Amendment is being voluntarily implemented by many countries. The Amendment bans the export of hazardous wastes, including lead acid batteries and lead wastes, from OECD countries to non-OECD countries. Under the conditions prevailing in many developing countries, the Basel Ban Amendment effectively encourages the importation of primary lead in order to bridge the domestic supply-demand gap. Primary lead is nearly as cheap as secondary lead. In such situations a comprehensive national strategy is required to reduce waste generation, enhance access to domestic sources of lead scrap and make recycling

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environmentally sound and economically viable (Jha & Hoffmann, 2000).

## **Battery Composition**

There are three general categories of lead acid batteries (see Table 2), but all operate according to the same principles. The major components of the modern recyclable lead acid battery are the electrodes (typically pure lead oxide and lead sulfate for the cathode, with the anode being a grid of metallic lead alloy with various elemental additives that might include antimony, calcium, arsenic, copper, tin and selenium), the electrolyte (dilute sulfuric acid), the separators, lead terminals and the plastic or rubber casing. The composition (by percentage weight) of a typical automotive battery is shown in Figure 1. The typical lead battery consists of 17% metallic lead, 50% lead oxide/sulfate, 24% electrolyte, 5% plastics and 4% (and reducing) inert residuals.

An average car battery weighs 17.2 kg and contains approximately 6 litres of sulfuric acid (pH = 0.8) and 9.0 kg of lead - equally divided between anode and cathode (Basu et al, 1991 cited by Environment Canada 1993). The electrodes (or plates) are constructed from a grid-like lattice filled with a hardened paste containing the active material. Grids are cast from a high purity lead and alloyed with antimony, tin, arsenic and copper to improve their mechanical properties. A few manufacturers may still use small quantities of cadmium, but this is rare nowadays.

Direct electrical contact between the plates is prevented by a separator that allows electric current to flow between the plates when carried by sulfuric acid. The materials used for separators include plastic (polyvinylchloride, polyethylene), glass fibres and rubber components (Environment Canada, 1993; UNEP, 1983).

Battery casings are typically constructed from polypropylene, which is also recyclable. However, previously non-recyclable hard rubber materials (such as ebonite) were often used. As a consequence, the materials used in battery construction may vary according to their date and location of manufacture (Environment Canada, 1993).

## **Results of the environmental technology assessment**

The findings of the assessment team are presented below.

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